**Experimentation Methodology**

To rigorously evaluate the proposed multi-agent reinforcement learning tutorial system, we designed a comprehensive experimental methodology comprising the following steps:

1. **Experimental Setup**
   * The system was tested using a simulated tutoring environment with a diverse set of student models, each exhibiting unique learning behaviors and engagement patterns.
   * Three coordination modes (hierarchical, collaborative, competitive) were implemented and compared.
   * Each configuration was run for 100 training episodes, with 5 independent runs per mode to ensure statistical reliability.
2. **Data Collection**
   * A total of 415 student interaction sessions were logged, capturing state transitions, agent actions, rewards, and performance metrics.
   * All results, including learning curves and evaluation statistics, were automatically saved for analysis.
3. **Evaluation Metrics**
   * **Average Reward:** Mean cumulative reward per episode, reflecting overall learning effectiveness.
   * **Learning Efficiency:** Rate of improvement over time, measured by the slope of the learning curve.
   * **Convergence Stability:** Variance in final performance across runs, indicating robustness.
   * **Statistical Significance:** Differences between coordination modes were assessed using ANOVA and post-hoc tests.
4. **Statistical Analysis**
   * ANOVA was used to determine if observed differences in performance were statistically significant.
   * Pairwise comparisons with Bonferroni correction identified which modes differed.
   * Effect sizes (Cohen’s d) quantified the practical significance of results.
5. **Reproducibility**
   * All experiments were conducted with fixed random seeds and documented hyperparameters.
   * Code, data, and analysis scripts are available in the project repository to ensure full reproducibility.

This methodology ensures that the reported results are robust, statistically valid, and reproducible, providing a solid foundation for evaluating the effectiveness of the proposed RL-based tutorial system.